Pressure Drop and Flooding Velocities for ¼-Inch Berl Saddles

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PACKED columns are used extensively in the chemical process industries. These versatile units find uses as distillation columns, quench towers, absorbers, strippers, and other heat and mass transfer devices. The various types of packings offer a wide range of selction as to surface area and pressure drop requirements.

Some recent process development work was carried out in a small packed tower absorber. To get maximum surface area of the packing material, but still use a packing similar to commercial tower packings, it was decided to use ¼-inch Berl saddles in the pilot plant tower, so that the pilot unit data could be scaled up to a larger commercial column.

To plan a study of process variables in the packed column, it was necessary to know pressure drop and flooding velocities for ¼-inch Berl saddles. The literature was checked, but no data on pressure drop and flooding velocities could be found. It thus became necessary to obtain these fundemental data experimentally.

The data presented here were obtained solely as a guide for setting up liquid and gas rates for pilot plant process development. They are not as extensive as might be desired for a purely academic study. The results, however, are consistent and should be useful for design of packed columns when ¼-inch Berl saddles are used.

The data presented here are valid only for liquids and gases similar to the ones used in this study and for the operating conditions of the column. Empirical methods for estimating the effects of fluid properties on pressure drop and flooding velocities are available (2). The estimations allow use of the data at other conditions.

DESCRIPTION OF EQUIPMENT

The apparatus used was the simple unit shown in Figure 1. Gas and liquid flows to the columns were measured with rotameters. Liquid flow entered the top of the column and discharged through a constant level liquid seal at the bottom. The gas entered the lower portion of the column and discharged from the top.

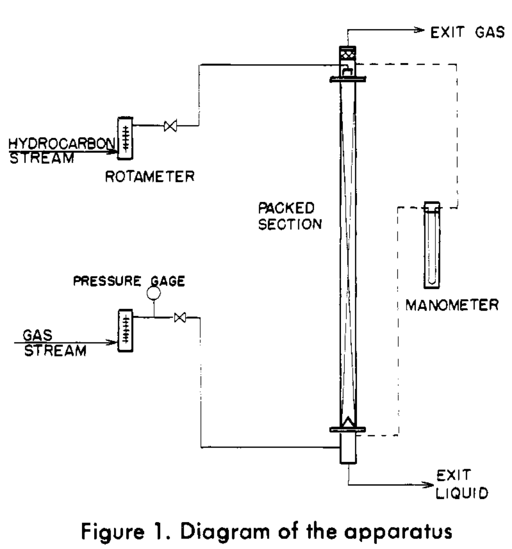

Figure 1. Diagram of the apparatus

The main part of the unit was a section of 2-inch diameter pipe 14 feet long. The entire length was packed with ¼-inch Berl saddles; no redistributors were used. The top of the pipe was flanged and attached to a 1-foot length of pipe. This column top had a side liquid entrance and distributed liquid to the top of the packing. Liquid flow was split and distributed through two pieces of ¼-inch tubing connected to a common tee. Six inches of wire mesh above the liquid inlet helped knock out liquid droplets entrained in the gas. The saddles were supported at the base of the column by an inverted perforated cone. Liquid drawoff was from the bottom of a 1-foot section flanged to the base of the packed section. Side entrance was used for the gas inlet.

The liquid feed was measured with a calibrated rotameter. The rotameter was calibrated with the actual hydrocarbon stream at the same temperature and pressure used in the experimental runs. Accuracy of the liquid flow measurements was probably within ±5%.

The gas flow was measured in a rotameter, calibrated with air since it was not practical to use the actual gas stream. A correction was made for the slight difference in density between the actual gas used in the study and air. The pressure on the rotameter was maintained at 5 ±0.1 p.s.i.g. The accuracy of the gas flow rate was probably within ±5%.

Pressure drop across the column was measured with a U-tube manometer using water as the fluid. The manometer had a capacity of 30 inches of water differential. The manometer could be read to ±0.05 inch of water.

RUN PROCEDURE

All pressure drop observations were made in generally the same manner. Flow rates of gas and liquid were set at the desired rates, and the column was allowed to reach equilibrium. Pressure drop reading usually became constant within 2 to 3 minutes after a change. Five more minutes were allowed for attainment of equilibrium. The flow rate and pressure drop were observed and recorded. This procedure was repeated for various increasing gas flows at four fixed levels of liquid flows. Column pressure drop became unstable at pressure drops of about 2 inches of water per foot of packing (28 inches of water for this column). At a slight increase of flow (5%), pressure drop exceeded the range of the manometer (30 inches) with no indication of reaching a constant value. This was taken as an indication of flooding.

DISCUSSION OF RESULTS

It was felt that pressure drop readings corresponded to equilibrium conditions. After 2 to 3 minutes of operation, readings became constant and remained so indefinitely.

Several times, radical changes were made in gas rate and then returned to some preset level. Within a few minutes the pressure drop regained its original value. Changes in liquid rate required a slightly longer time to reach equilibrium. Liquid and gas volumes were essentially constant throughout the column.

The data are shown graphically in Figure 2. Some slight scatter of data occurs, but the lines drawn represent the probable average for correlation. The physical properties of the gas and liquid streams are shown in Table I.

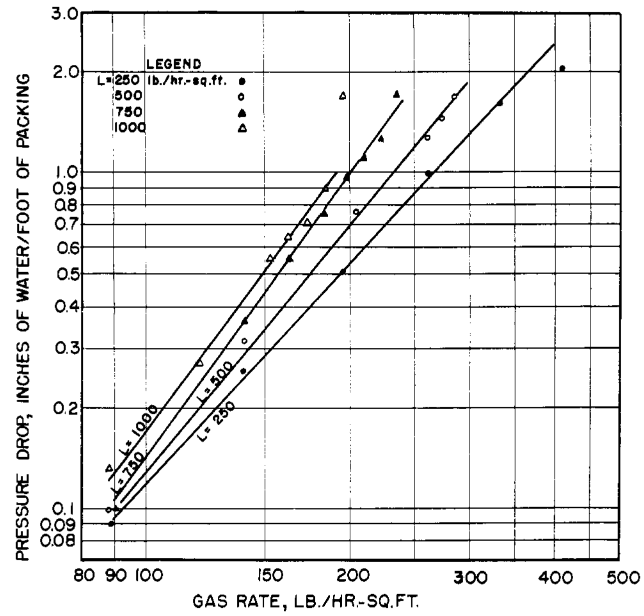

Figure 2. Pressure drop for the ¼-inch Berl saddles, data taken from 2-inch diameter column

Table I. Physical Properties of Fluid Streams

Hydrocarbon, liquid	Density, 0.774 gram/cc. at 100° F. Viscosity, 1.25 centipoise at 100° F. Surface tension, 25 dynes/cm. at 100° F.
Refinery gas	Average molecular weight, 35 Viscosity, 0.0134 centipoise at 100° F.

Table II. Comparison of Flooding Velocity Data

	G_{flood}	
L_{flood}	Predicted from Equation 1	Data of Elgin and Weiss
1928	154	135
3480	115	92
6500	84	65

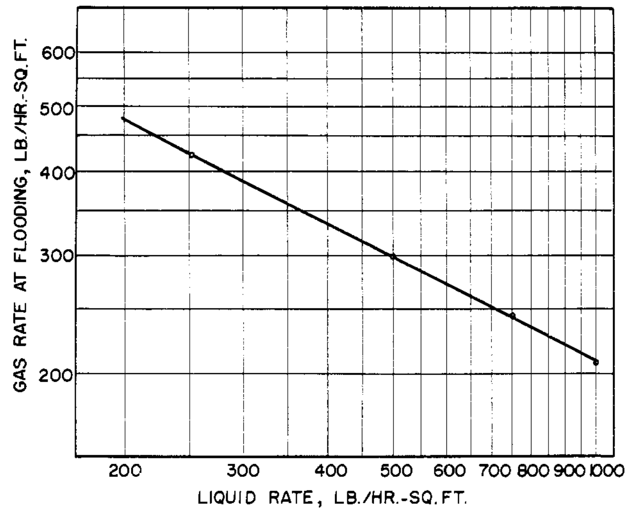

Figure 3. Flooding velocities for ¼-inch Berl saddles, data taken from 2-inch diameter column

The flooding gas velocity is shown plotted *vs.* the corresponding liquid rate in Figure 3. The correlation appears quite satisfactory. The equation of the line is:

$$G_{flood} = 6800\ L_{flood}^{-0.50} \quad (1)$$

After this study was completed, some data on flooding velocities for ¼-inch Berl saddles were found for liquid rates above the range studied (*1*). Extrapolation of Equation 1 above the experimental range gave predicted values of G_{flood} which are about 20% higher than the data of Elgin and Weiss (*1*). The Elgin and Weiss data are for the air-water system at 21° C. No corrections for the slight differences in physical properties were included in the calculations. The comparison is shown in Table II.

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NOMENCLATURE

G_{flood} = gas rate at flooding, lb./hr. sq. ft.
L_{flood} = liquid rate of flooding, lb./hr. sq. ft.

LITERATURE CITED

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(2) Leva, Max, "Tower Packings and Packed Tower Design," United States Stoneware Co., Akron, Ohio, 1953.

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